Port planning for the Port of Vigo using port and city integration criteria

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Abstract—**Project planning and architectural management of a port area should include many variables, it must be in harmony with its environment and its historical development as the key to successful integration. This article explains the elements which should be taken into account when doing such planning by describing the proposal presented on the "Concurso public internacional de ideas para proyectar la ordenación urbanística y arquitectónica del área central del puerto de Vigo", with the aim of sharing comprehensive applied design philosofy, it will inspire and help future designers. Creative imagination is great added value to engineering creations, but should not overwhelm functionality and sustainability, but to be in harmony with them. The maximum aesthetic expression in engineering is achieved as the product of the conceptual elegance of the functionality of the structures.**

Keywords- Modern port city; Port-city relationship; Harbor-town planning

I. INTRODUCTION

Since the last decades of the XX Century, parallel to the great changes experimented by the transport system in global terms (linked to new forms of production, commerce and consumption), the environmental variable has gathered prominence in the frame of planning and transport infrastructure construction [1].

Transport services exist to offer possibilities of movement both for freight and persons, and to facilitate the distribution of services between two given locations. Transport does not guarantee the development of the regions if infrastructures are not planned adequately, neither does it without the appropriate means of transport for the freight to be mobilized, and that could limit the mentioned development of the regions [2]. Infrastructures establish territorial potentialities derived from accessibility able to create a bunch of comparative territorial advantages [3].

Concerning engineering, most of the analysis related to the establishment of a new infrastructure, the operational workout of a new network or the incorporation of technical improvements in the different transport system modules usually supposes the outbreak of a series of positive effects, both from the social and economic points of view [4]. [5] maintains that from the XIX Century, the paradigm of causality has accompanied almost all analysis that intended to study transport infrastructures as an element inserted at a given location [5]. Therefore it is very common to hear that the construction of a new linear infrastructure, the construction of a bridge or the establishment of new transport services, for example, will bring together the economic development, as well as significant social changes of close populations and of the global structure.

In the particular case of ports, port spaces that, due to different circumstances, are susceptible of transfer to public use, constitute the generally denominated waterfronts, which is of special attraction for the development of ludic and recreational areas [6]. During the last two decades, these waterfronts have been developed in several cities obtaining, in general, a wide acceptance from citizens. Some representative locations affected are Baltimore, Nueva York, San Francisco, Buenos Aires or Barcelona [7, 8].

The economic decline of traditional port zones at the end on the 90s, released considerable land extension for urban reconstruction, most of them near the heart of the city centre [9]. The development of the land property industry has capitalized these released assets, therefore, from the [9]it is also concluded that a better water quality is proved to be an important precursor for the economic regeneration of the waterfronts.

Every project has to be in harmony with its environment and historical evolution, and that has proved to be the key of success for its integration, being the field of ports no different. Continuity has to be given to this evolution, respecting the nature of each of the elements involved. Concerning port projects, every intervention entails an action on the economic structure and produces an income modification. In the study

made by [10] the evolution of the impact of economic incomes and land uses due to coastal improvements is analysed during different periods of time. The urban evolution rhythm is being accelerated by social, economic and architectonic transformations in port zones, which are becoming high standing residence zones as well as attracting new industries, recreational zones and attracting poles for transport [11].

II. PLANNING MODEL FOR THE PORT OF VIGO

The transport sector has an unavoidable responsibility in the socio-economic development of nations due to giving a necessary service to activities related to production, services and movement of persons [12]. That is why the development of transport systems should be planned based on integration functions (structuring) that transport is meant to specify, and those functions could vary from one region to another, even if they are from the same country. Integration of city and port goes beyond a physical integration into the urban grid [13]. It produces a synergic effect in potentiating the zone, improving the results expected only by eliminating barriers between port and city.

Port activities are benefited by the increase of citizen participation in those activities thanks to the creation of cultural, recreational or commercial areas. The city is benefited from the creation of an area with enough importance to be considered as emblematic and potentiating its port as one of the most important scales of each façade [14].

Concerning the case study, Vigo defines itself as a port and enterprising city located in the geographic centre of Galicia-North of Portugal Atlantic Euro-region, and the port of Vigo is the main port in Galicia concerning high value manufactured freight transport, extending its influence area to the North of Portugal and the Castilian Meseta (Figure 1).

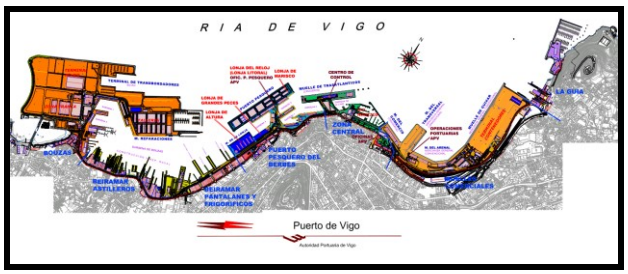

Figure 1. Port of Vigo Plan. Source: Autoridad Portuaria de Vigo.

The port of Vigo, as a general interest commercial port, is a key instrument for the development of a productive economy in the area and a strategic element in the logistics chain for the companies into its hinterland.

The port of Vigo is the scenery for half the Vigo economic activity and represents 40% of the Vigo Gross Domestic Product. That is why it has to make the necessary efforts to evolve and adapt to the necessities created in the 21st Century, such as draft and length dimensions for modern ships.

Increasing its capacity without renouncing to the maximum respect to the environment is an indispensable condition for the port of Vigo to keep leading traffic and having the role of dynamic focus of the Rías Baixas zone economy, as well as a first order reference among European ports in the Atlantic strip. Port users need a harmonic development of the port and the city, both becoming a strategic location in the rising cruising business, as well as an increase in the quality of life for the Vigo zone inhabitants. Therefore, it is necessary to keep together port and city considering that inhabitants do not only live in the zone, but also work and use the services linked to the existence of this historic port.

In relation to the above-mentioned principle, the integral planning of the port is faced in order to reinforce its role as an essential component of the economic and industrial development of the region, due to both its dimension and operability, extending the mooring lines and increasing the draft available, and so contributing to increase traffic, becoming a business opportunity for enterprises in particular and the whole society of the region in by extension.

Among all projects that are being carried out in the zone of Vigo, the most significant are the following:

- Intermodal terminal in Bouzas. New ro-ro ramps. With this action it is intended to achieve the double objective of optimizing the current traffic service and attract new traffics, taking advantage of the synergies derived from these traffics, optimizing existing port infrastructures and potentiating the port of Vigo as an important international port.
- In the Central Area: Fishing, Ocean Liners and Commerce: In the fishing port, rehabilitation of the #1 shipbuilders premise in the #2 basin (the largest of them all), for different port uses; at the Muelle de Trasatlánticos, the re-conditioning and re-paving of the port esplanade, paving and re-conditioning of the ocean liners zone and the A Laxe basin, located next to the urban zone of the port, and so there is continuity in the transition between port and city and the public use of the explanadas is potentiated, maintaining the current port activities and adding the new intended activities: cruise traffic, nautical and recreational use and estuary transport; and at the Muelle de Comercio the re-conditioning of the warehouses at Muelle de Comercio and berthing dolphin at the Muelle de Comercio.

TABLE I. . PORT OF VIGO BY THE NUMBERS. YEAR 2011

Description	Amount
Total port traffic	4328562 t
Total general freight traffic. Year 2011	3456495 t
Total containerised freight	2313917 t
Total bulk traffic	512412 t
Total TEUS moved	212119
Total new vehicles	665511 t
UTI´s Ro-Ro	13506 units

Fresh fishing	84264 t
Frozen fishing	689711 t
Granite	271618 t
# of cruise scales	118
# of passengers	252829
"*Business amount*" 2011	24.5 mill €

Source: Autoridad Portuaria de Vigo 2011.

Also the PLISAN Logistics Platform, located in the villages of Salvaterra de Miño and As Neves, considering that all of them will contribute to its position as a great port in the European Atlantic façade.

The Vigo estuary constitutes a formidable natural port of exceptional landscape beauty. It is a natural port of 25 km with a total surface of 11238 ha.

It is a bay protected by the extraordinary Cíes Islands, that are three, called Monte Agudo, Faro and San Martín with two mouths that give access to the port one in the Northern side (2 km wide) and another one in the Southern side (up to 5 km wide).

It is an estuary with a draft up to 40 m that gets narrowed in Rande and widened again to form the San Simón inlet, with a total surface of 932 ha, and the homonymous island.

One of the most privileged natural ports in the world, the port of Vigo is also a top fishing port, base of a fleet operating around the world. The port of Vigo is famous for its cruising traffic, automobile import-export, commerce and scenery for international nautical competitions, and with a long tradition in ship building.

Since 1869, when the book "*Twenty Thousand Leagues Under the Sea*" was published the greatest publicity of the Vigo estuary was made as a full chapter was dedicated in his inmortal novel.

A. New dimension of port spaces

The case study is based on the "*Concurso público internacional de ideas para proyectar la ordenación urbanística y arquitectónica del área central del puerto de Vigo*" (Public competition of ideas for a Project on urban and architectonic planning of the central area in the port of Vigo). Vigo is a compressed city due to orography and needs open spaces. An extension of the leisure port and the green zones associated, along with the leisure activities carried out there makes possible to visitors to get into the sea.

By creating those spaces it was intended to build more than a commercial zone, trying to help citizens get identified with the sea culture, together with the creation of a leisure park with the marine life as main topic.

B. Self-financing and sustainability

The feasibility of a Project is necessarily linked to its sustainability, both in economic and environmental points of view [15]. The project focuses on the self-financing, proposing a construction and exploitation system feasible for the port community so that it does not act as a burden for future development.

Some European and North American cities are introducing modifications and significant improvements in their pattern of urban design and mobility in the frame of urban-environmental recent trends, such as "Smart Growth" or the New Urbanism [16]. The relationship between port and city and port planning is not alien to the new currents transcribed through *"Smart Cities"* and derived into the more detailed *"Smart Ports"*.

Currently, there is a wide bibliography related to the debate on sustainability and the environmental implications of transport both in terms of infrastructure works development and mobility. Among the topics currently linked to the analysis of environmental aspects of transport, it is worth remarking the study on transport causal relationships on the environment (usually in terms of "impacts" – [1]). The most specific example is given by the Environmental Impact Assessments (EIA) used as legal tools based on technical reports, where an analysis on environmental significant impacts is presented. Concerning environmental sustainability, it is a social imperative to have the commitment to preserve the assets of nature [17].

The Project presented is, above all, functional. The project master lines have surged as a result of a simple and practical structure. However, the solution searched had to fulfill the requirements on functionality and sustainability not as corrections, but from its very first conception.

C. Safety and security

An important challenge presented with this Project was to make the port accessible to the public, but guaranteeing at the same time its privacy, safety and security both in terms of cruising and concerning the International Ship and Port Facility Security Code (ISPS) [18], and in terms of recreational port users or existing port facilities.

All the above requires multi-use surfaces with enough flexibility to deal with every single use. Parallel to that physical devices have been searched that enable the mentioned flexibility to be part of the global design, e.g. viewpoints [19].

D. Planning of quotidian issues

As time goes by, the port has become a platform for the citizens to develop their quotidian activities [20]. It is not only the persons that earn their living from the port's assets [21], but also for persons that use the port as a link to reach the opposite margin of the estuary, those who go to fish markets on a daily basis or for recreational activities [22].

All the above derived in a trend to maintain the existing port facilities to avoid causing any inconvenience to port users. The new design proposed, as it will be shown in the following sections of the present paper, is conceived according to these principles.

III. PORT OF VIGO EXTENSIÓN PROJECT

The proposal of extension is an alternative that aims at offering the best proposal for the new planning and development of the port zone located at the west end of the Fishing port's basin 2 (see figure 2) and the western beam of the Muelle Transversal (Transversal Dock), including the link with the Jardines del Arenal (Arenal Gardens), assigning different uses, mainly of public nature, for this port zone.

A. Proposal of planning based on port and city integration

A difference from the suggestion made by the port and the proposal described in the present paper is the proposal of building a cruising dock separated from the existing one, deriving in some advantages for its exploitation, and justifying this proposal as the most rational. From the existing zoning the commerce zone is maintained, but the rest is modified due to a different configuration proposed in the proposal.

The dock proposed maintains the current alignment with an extension, continuing with a swerve to the transversal dock, resulting in a sheltered zone with two entrances, one of them beside the existing cruising dock and the other one beside the transversal dock (see figure 2). This structure is linked to the change in the alignment by a walkway designed as an extension of streets Concepción Arenal and Colón, which are an integral part of the urban grid, and regaining the commerce dock as an urban space.

The image of the dock and the walkway planning (see figure 2) is similar to an arrow introducing the city into the estuary. This walkway divides the new leisure port in two basins, making a more rational solution than the initial proposal. Therefore, it is possible to maintain the current location of estuary traffic without altering the access not the itinerary timetables.

This dock is designed to receive two cruisers simultaneously with lengths of more than 300 m, few existing cruisers being longer than that [23]. Both berths are independent, making possible the access of passers-by when they are freed. For cruise passengers an edifice was designed at the end of the dock. Apart from that there is a terrace with a viewpoint that makes possible to enjoy great views of port, city and estuary.

Figure 2. Proporsal planning.

The dock enables the water renovation thanks to a typology based on separated caissons linked to each other by beams, as if it were a succession of bridges. The structure also includes flaps that cover the emerged part of the structure, preventing the agitation inside the new leisure port. The walkway, with the same structural walkway but for the flap, makes possible to keep the sunlight illuminating zone under the platform.

The new leisure port should have new berths in the best possible conditions of safety, security and comfort, both in water and land accesses, and with all the necessary facilities [24].

The headquarters and the sailing school should have a hexagonal esplanade at the entrance of the port without impeding the views from the city (see figure 2).

Some elevated viewpoints could be built aiming at preserving cruisers security according to the ISPS Code [18], housing 200 parking places under its surface and serve as stands for different shows at A Laxe basin.

It is necessary to foster the relationship between port and city to equip the zone with cultural facilities, the current Maritime Station with remodeling would aim at housing a cultural complex that would include a marina museum, exhibition rooms, and a museum of fluid physics. Also an aquarium could be built, linked to the museums through galleries under the eastern viewpoint. On this location there would be a gyratory restaurant, flanking the entrance to the leisure port's western basin, opposite to a tower of communications located at the west end of the new cruisers dock.

The creation of a market for products derived from fishing activities and also to taste local fishing products, as well as for occasional street markets related to fishing that would enhance the relationship between the port and the city.

The construction of a pedestrian walkway over the road would enhance the accessibility of this zone to link the port and the city and there would be a leisure zone with restaurants, gardens and a multi-use space for temporary exhibitions.

It would be necessary to provide the zone with public parking places of great capacity to boost the mobility around the port facilities.

In the frame of the shore protection policies, a key element in coastal planning in areas of great usage is the existence of a boardwalk [25]. A boardwalk as conjugated axis for port articulation around the city façade, linking among each other all the affected zones would be built.

Lastly, and in order to boost the public nature of the common zone of the port, there would be a tram to link the affected zones, taking advantage of the existing paths, that would work during the summer season.

B. New zoning

The new zoning is derived from a concept change that this proposal means. First of all, the project is supported by the extension of the axis defined by the streets Colón and

Concepción Arenal, creating a wedge that enters the sea. Secondly, a leisure area is created around the A Laxe basin (see figure 3). And thirdly, fishing zones are regained and linked to the city through several accesses (see figure 3).

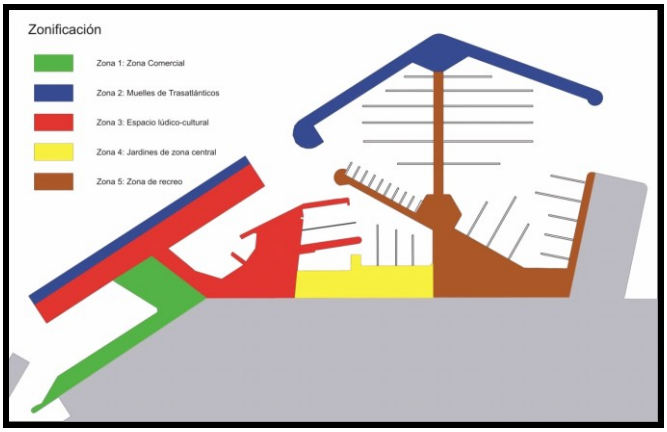

Figure 3. Proposed zoning plan

C. Design criteria and port and city solutions

The range of criteria to be considered has been as wide as possible, evaluating not only technical aspects, but also, more importantly, the impact and consequences in socioeconomic and environmental terms. The general idea source of these criteria is potentiating the port of Vigo as an integral and indissoluble part of the city.

The basic criteria used were: the creation of a public area as accessible and attractive as possible, and maintaining the necessary conditions of safety, security and functionality in a sustainable way in economic and environmental terms.

To sum up, port and city necessities are the main criteria used in the design of this proposal and the main conditioning points.

The estuary traffic is defined by the necessity of having promptness, fluency and comfort concerning mobility. That implies, firstly, the necessary immediateness from the boarding dock to the port entrance, considering the existing limitations in speed inside of the port. Secondly, the estuary transport system has to be close to the urban transport system, the Maritime Station and the boarding zone. It is necessary to have a well-articulated network similar to the existing one, causing minimum inconvenience to passengers. The first design condition suggests a dock close to the port entrance and the second proposes to maintain the estuary boarding station in its current location, thus concluding that the current entrance for ferries should not be closed. That is solved by linking the cruisers dock with the city.

The key of the design presented in this paper focuses on the extension of the cruisers berthing line, and also providing a perimeter to the leisure port with. The necessities required were of 700 m of new berthing line, and permitting an entrance between each other. Concerning functionalities, there is no need for them to be together (see figure 4). This new arrow-shaped dock is totally independent, and shall be provided with its own attention point for passengers, and it can be set as one of the most emblematic buildings of the action, being able to shelter some of the largest cruisers in the world, such as Queen Mary II [26].

The area destined for cruisers (see figure 4) has to be a restricted area, in which all the activities related to this kind of traffic, such as boarding, boarding control and accesses for tourist operators' buses. The access control is compatible with the possibility to permit access to pedestrians by using mobile barriers located under the walkways.

The great surface of sheltered water is created with the new dock and shall be organised in the most rational way possible for the comfort of the users. That means that, firstly, the pier zone – a pier being a little docking structure that enters the sea – this maritime infrastructure has to have easy accesses for the users' vehicles, and secondly, its length is limited to increase comfort for users. Moreover, the piers have to be disposed so that navigation is comfortable, intuitive and safe for vessels.

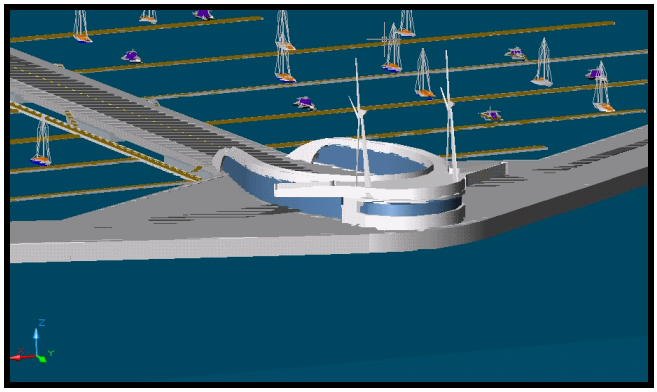

Figure 4. Computer graphics of the passengers' attention centre and the new ocean liners dock

There are series of necessities concerning the equipping of the affected zone that have to be solved. The first is related to the parking zone, quite limited in the range of the port with its current configuration. The second refers to green areas in the port and its surroundings. The existing ones are to be preserved and some other would be added in the fishing zone and at the eastern end of the commerce dock.

The physical integration of the port and the city is achieved through two actions: the extension of the axis Colón-Concepción Arenal, through which the city enters the sea, and the construction of three new pedestrian accesses, with which the port is inserted in the city. The three new pedestrian accesses, along with the existing ones, confers the port area a greater accessibility, and so dodging the barrier meant by the existing road in the zones that are yet to be underground (see figure 3).

In the design of the typology for the new dock, the necessity of creating a permeable structure to water had to be considered, and so enable its renovation, but in a way that it protects the leisure basin from waves. This disjunctive was solved by separating the caissons and adding a flap.

Concerning the bathymetry, an analysis of necessities had to be done linked to the existing depth in each zone in order to conclude that depths were enough for the foreseen use of each

zone, and preventing the action to be moved away from the coastal structures - the first consequence was an increase the total cost, letting alone environmental implications (see figure 5).

Concerning geomorphology and geotechnical implications, the different zones have to be studied in detail in order to set a load distribution. Concerning the present proposal, the area where the eastern entrance is located was avoided, and the tower of telecommunications was moved to the end of the western dock, which was considered more appropriate for the configuration proposed (see figure 1).

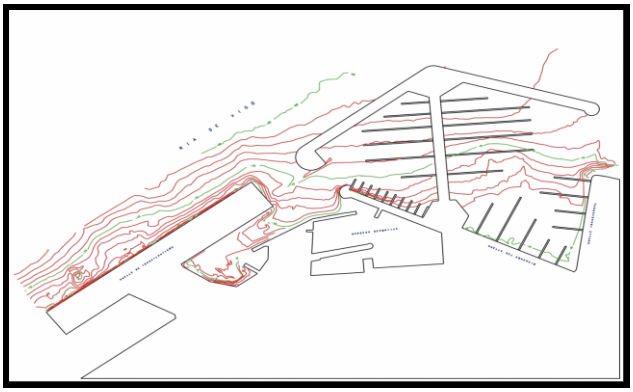

Figure 5. Bathymetry

D. Environmental sustainability

In ports certain environmental problems usually occur, and they are solved with correction measures [27, 28]. While planning the alternative proposed an original solution was given to the problems presented with a preventive rather than corrective focus. It is necessary to face and solve the environmental problems linked to cities that may require other strategies for its production, control and maintenance [16].

As an example, concerning greenhouse effect gas emission in global terms, transport is responsible for up to 13,1% of total emissions [29] and for 22% of those emissions coming from energy consumption, only behind the generation of electric energy and heating [30]. The increase of commerce transactions has derived in the ports being critical logistics nodes; the increase of the capacity of vessels and the re-structuring of routes that incorporate transfers present a great challenge for the competitiveness of the countries [29].

The enclosure of port areas brings aside the blockage of waters and the accumulation of remains, and thus producing septic conditions [9]. The typology of dock chosen in this proposal [31] enables the circulation of water under the platforms avoiding the existing physical barriers that prevent the renewal of waters, and at the same time works as a barrier itself for floating remains thanks to the flaps incorporated. This system is formed by a bombing station that would be placed inside the building that currently houses the maritime station, in the area that the proposal destined for the hydrodynamics museum. Apart from that, it would be connected to the sea and the basin through conductions that would work at pressure. The renovation of the basin waters will be completed in around three days.

Concerning environmental considerations, the following requisites have to be accomplished for a minimum water quality:

- Maintain a concentration of coleiforms of less than 1000/100 ml.
- Prevent stinks, foam and water colouring in the basin.
- Boost the renovation of the maximum water possible with an adequate bombing plan.
- Prevent anaerobic and eutrofization conditions, minimizing NOx and Pox maintaining a high percentage of dissolved oxygen and reducing the sediment density with a high percentage of organic remains.
- Reducing polluting remains and thus preventing wastes.
- Maintaining a balanced salinity.

Moreover, there would be a primary treatment to eliminate wastes for water coming from the sea before being introduced in the basin. The mud dredged both from the A Laxe basin and from the foundation of caissons, would be used as filling, if it is reasonably feasible, for the esplanades build in the new dock for ocean liners. The mud is a bad quality filling material, but its use as filling is reasonable as loads in that area are not going to be demanding.

IV. CONCLUSIONS

This proposal intends to potentiate the possibilities of port and city as a single unit. The philosophy was to design a port that projects the city to the future to a more modern concept as a key factor in the growth of the region.

It is a project that integrates several factors such as environmental sustainability and self-financing concerning the future, as well as comfort, functionality and design in present terms, aiming at humanising the port for it to become a space where the citizens can participate, and thus achieve the harmony intended for port and city.

The new port planning would give response to a great demand, enabling the release of other port zones currently occupied in other activities and therefore achieve a better port planning.

And last, and probably most important for the citizen, the port is developed as a platform for the growth of the city, a space for extending the city into the sea and a space for the union of two cultures such as the urban and the marine ones, that have been traditionally separated.

The creative fantasy is a great added value for engineering, but it should not be in detriment of functionality nor sustainability. The maximum aesthetic expression in engineering is reached as a result of the conceptual elegance of functional structures.

A good design should start by understanding the idiosyncrasy of the location in order to design creative and

imaginative solutions and integrating local cultural and custom values, and thus boosting a fast and deep acceptance.

The proposal presented in this paper was awarded a prize at the "*Concurso público internacional de ideas para proyectar la ordenación urbanística y arquitectónica del área central del puerto de Vigo*" (Public competition of ideas for a Project on urban and architectonic planning of the central area in the port of Vigo), where numerous international prestigious designers, architects and engineers participated. The added value of this proposal was to design an integrating solution linking city and port, solving all the necessities satisfactorily. It was achieved from using a critical spirit that should always be part of a creative process.

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